

Ex. Doc. No. 23.

## HOUSE OF REPRESENTATIVES.

### BUFFALO HARBOR.

### LETTER

FROM

### THE SECRETARY OF WAR,

IN ANSWER TO

*A resolution of the House of Representatives of the 18th of December, 1848, relative to the different plans for the improvement of Buffalo harbor, New York.*

JANUARY 6, 1849.

Referred to the Committee on Commerce, and ordered to be printed.

WAR DEPARTMENT,  
Washington, January 5, 1849.

SIR: I have the honor to transmit herewith, in compliance with a resolution of the House of Representatives of the 18th ultimo, a communication from the colonel of the corps of topographical engineers, with a report and plan of the board of "engineers appointed under the bureau of topographical engineers, to examine and report upon the different plans for the improvement of the harbor of Buffalo, New York."

Very respectfully, your obedient servant,

W. L. MARCY,  
Secretary of War.

Hon. R. C. WINTHROP,  
Speaker of the House of Representatives.

BUREAU OF TOPOGRAPHICAL ENGINEERS,  
Washington, January 3, 1849.

SIR: I have the honor to transmit the report in reference to Buffalo harbor, called for by a resolution of the House of Representatives of the 18th December.

The object of the board was to devise a harbor at Buffalo, adequate to protect the shipping of that place and of the lake, from the disastrous effects of storms, to which it is now exposed.

To accomplish this object the board suggests two plans, each being the construction of a breakwater. One places the breakwater in a position northwardly of the present light-house pier; the other in a position southwardly of that pier. Each would accomplish the object, but the board evidently lean in favor of the second, for which their reasoning will be found in the report.

The southern position for the breakwater establishes a secure and spacious outer harbor. The northern position also accomplishes these objects, and in addition protects the present entrance to Buffalo creek, or to what is usually denominated Buffalo harbor. It appears to me that this advantage is one of more importance than it seems to have had in the views of the board.

The southern breakwater would probably lead in the end to the opening of a communication with the present harbor, near a point on the map marked "south channel," the cost of which would be an addition to this plan, and its effects upon the present harbor, whether beneficial or injurious, is matter of doubt.

Part of the northern pier is in comparatively shoal water. Embracing these several considerations, the northern breakwater would be the least costly structure.

The present light-house pier should not under any view be extended further into the lake. This opinion is, I think, a very sound inference from the reasoning of the board upon the effects of storms at this end of the lake; and it would, without doubt, be advantageous to remove or seriously modify the existing "Black Rock pier."

Its chief tendency now is to increase inundations at Buffalo in times of storm.

Respectfully, sir, your obedient servant,

J. J. ABERT,

Colonel of Topographical Engineers.

Honorable W. L. MARCY,

Secretary of War.

BUREAU OF TOPOGRAPHICAL ENGINEERS,  
Washington, March 14, 1845.

SIR: In obedience to an order of the War Department, dated 22d February, 1845, a board of officers will be convened at Buffalo on the first Monday of April, 1845, to examine into and report upon

the plans for the improvement of that harbor. The board will consist of

General J. G. Swift.

Lieutenant Colonel James Kearney.

Major M. Trumbull.

First Lieutenant Woodruff will act as recorder.

The board will not merely examine and report upon such plans as have been submitted by the bureau, but into any which shall be submitted in writing to their consideration by the city councils of Buffalo.

Very respectfully, your obedient servant,

J. J. ABERT,

*Colonel Corps Topographical Engineers.*

General J. G. SWIFT,

Lieutenant Colonel J. KEARNEY,

Major M. TRUMBULL.

In pursuance of the above order, the board met at Buffalo, on the 7th April, 1845; all the members present. Lieutenant Colonel Kearney in the chair.

The board resolved to inform the authorities of the city of its having assembled, in a letter to the mayor, in the following words:

BUFFALO, April 7, 1845.

SIR: In pursuance of the order of the Topographical Bureau of the 14th March, 1845, the board, consisting of Lieutenant Colonel Kearney, Major Trumbull, and General Swift, has assembled in this city, and is ready to receive any communication which the mayor and common council of the city may be pleased to make to the board.

By order of the board:

J. C. WOODRUFF,

*First Lieutenant U. S. Topographical Engineers, Recorder.*

To his honor the MAYOR.

The recorder waited upon the mayor with the above communication. The mayor stated, that the communication of the committee appointed by the common council to report on the subject of the harbor improvement would be immediately presented to the board. In the evening of the same day a communication was received from the mayor, laying before the board the proceedings and report of the common council on the harbor improvement, together with the plans of Judge Burawell, R. H. Heywood and others, Henry Lovejoy, and of T. C. Love and others.

The next day the board proceeded to read the several plans submitted by the common council, commencing with the views of the common council itself; that body is in favor of straightening and enlarging Buffalo creek, and continuing the sea wall to the high ground, and of such additional plans as may be deemed necessary,

and the common council believe that the light-house and Black Rock piers cause injurious rises of water in westerly gales. See document No. 1.

The next plan submitted by the common council, is that of Mr. Burnwell, which recommends the construction of three canals from the Hamburg canal, one of the three to enter the creek and thence from the creek into a dock of thirty acres in extent, the other two of the three canals to extend from the Hamburg canal into the same dock, and from the dock west, into the creek, also another dock of twenty acres, to be placed between the bend of the creek and the lake, and to be connected with the creek near its mouth by a canal running parallel with the lake shore. See document No. 2.

The third plan is from Mr. Heywood and 1,600 citizens of Buffalo, which recommends the straightening and enlarging the creek, and extending the sea wall. See document No. 3.

The fourth plan is from Mr. Lovejoy, who proposes to make a channel through the elbow, and to open a south channel near the bend of the creek, and to place a breakwater corresponding to the plan submitted by the bureau. See document No. 4.

The fifth plan is that of Mr. Low and seventeen other citizens, proposing, 1st, to remove the elbow; 2d, to dredge out the creek as far eastward as may be deemed expedient, and 3d, to extend the present light house pier. See document No. 5.

The sixth plan is from Mr. Palmer and four other citizens, and proposes to widen and deepen the creek, and open the south channel, and thence extend a pier into the lake and build a protecting sea wall. See document No. 6.

In order to judge of the comparative merits of these several plans for a harbor at Buffalo, the board commenced their observations upon the position of the city in reference to the approaches to it from lake Erie, and to examine the creek and the bay, the currents of water, the shoals, and the action of the water upon them and upon the shores, and to the collection of facts in reference to the motion of the water and the ice; in reference to storms, floods, prevalent winds, and to the passage of the surplus water of the lake into the Niagara river.

On a view of the vicinity of Buffalo, and its adjacent waters, one of the first impressions is the small difference of level that exists between lake Erie and the shore, south and southeast of the city, and of the liability to overflow from the lake. This view, and the inspection of the map of lake Erie, exhibit the bay of Buffalo to be formed by the termination of the Canadian and United States shores, in an acute angle at Buffalo, and at the commencement of the outlet of the lake into Niagara river.

The natural motion of the water of Lake Erie is towards Buffalo. The most prevalent winds on this lake are from the southwest; consequently, during the prevalence of such winds, the acute angle of the bay becomes a funnel-formed receptacle of the water forced onward by the wind and natural current; and when this wind becomes a gale, the waters rise above the level of the shores



near Buffalo, and spread over the low lands to the south and southeast of the city, and at Sandy Town. Again, the prevalence of the northeasterly winds produces a similar effect at the western extremity of the lake, causing the water to rise there, at Toledo, in the period of a northeast storm, to a height of six feet above the ordinary level of the lake; and it has been observed that when a strong easterly wind has been succeeded by any sudden change of wind to the southwest, that then, by the re-acting force of the returning water, added to the natural current and western gale of wind, an increased height of flood is produced at Buffalo, over and above ordinary floods, as in October, 1844, to ten feet above the ordinary level of the lake; and that there may be at Buffalo a flood corresponding to the sum, and at Toledo a flood corresponding to the difference of the forces; and at Dunkirk, last October, the flood stood two to three feet below the level of that at Buffalo.

As long as a gale from the west continues in force, the water would continue to rise and spread near Buffalo; proving that the outlet of the Niagara river is not sufficient in times of flood to carry off the accumulating waters as rapidly as they are pressed on by the gale; and, consequently, the continuation of the gale would continue to elevate the water until the gale had crowded the water to its maximum height; that is, to that elevation when the accumulated fluid would overbalance the power of the wind, and then commences a reflux towards an equilibrium.

The storm of October, 1844, was preceded and accompanied by something worthy of remark, having reference to the theories of Messrs. Redfield, Reid & Espy, such as that there was an entire calm at Buffalo after a northeast wind of several days duration, and which was succeeded immediately after that calm by a violent southwest wind, indicating that Buffalo may at first have been the centre of the storm. From all that we have learned on inquiry, the returning waters to the east end of Lake Erie were in waves similar to the flowing tide near the head of the bay of Fundy.

*Of Buffalo Bay.*—This bay may be considered as an outer and inner bay; the former bounded by the points of Abino and Sturgeon, and the latter by Four-mile and Windmill points. As the bay narrows towards Buffalo, the water becomes generally of a depth varying from 18 to 27 feet, and in the Canadian channel 42 feet have been found.

Where the water is 18 feet and less in the bay, there it is entirely over rocky shoals; and, in general, the bed of the whole bay is rocky, with here and there some spots of clay, and some of sand. The bed of the bay in the channels nearly opposite Buffalo creek commences to slope to the north. The bay is about four thousand yards wide from the mouth of the creek, and the river one mile below, to the north, is narrowed to seven hundred and forty yards. The rocky bottom of the bay has many of its inequalities filled with sand or clay, or both. The bed of the bay, for

a mile south of the pier, is also of rocky and clay formation. The inner bay contains numerous rocky shoals. The channels that exist between these shoals are of sufficient capacity to carry off the ordinary outpouring of the lake, and it is the opinion of the board that it was an error to obstruct the channel between Bird island and the American shore. The construction of the Black Rock pier at and near Bird island, which was made under an appropriation of Congress, has caused a counter current, which causes still water adjacent thereto, and which, combined with the action of the waves coming from the southwest and around the light-house pier, has contributed to abrade the beach of Sandy Town bay, and therefore this evil should be remedied. Removing the dam from the space formerly occupied by the Bird island channel, and constructing a series of cribs on the ten feet water line of the bay, from the vicinity of the mouth of the creek to the entrance of Black Rock harbor, would secure the object as indicated upon the plan, and would involve an expense of

The water of the lake flows with a very small difference of level until within the bay near Buffalo, where the water commences to flow over what may be termed the brim of Lake Erie basin, and soon increases in rapidity. Of the several channels, the deepest is near the Canada shore; the deepest channel, which was nearest the American shore, has been closed by the traverse pier, thereby forcing the current first into a westerly and then a northerly direction. Thus, to the outlet of Lake Erie is given various directions to the currents, and several peculiar forms to the sections of the water passages, and through all of which some *twenty millions* of cubic feet of water flow in every minute of time. A patient examination and measurement of the forces and resistances influencing the currents, is requisite to give the elements of the upward curve of the surface of the currents. The details necessary to determine these questions accurately require much time and favorable opportunity; sufficient, however, has been observed to justify the conclusion that it would not be advisable to place obstructions in any of the channels beyond that which may be essential to secure a harbor.

*Of Buffalo creek.*—This creek is formed of the Casenove, Seneca, and Cayuga branches, and from the junction of the two latter the fall, or difference of level, to the creek of Buffalo is nearly fourteen feet. For nearly three miles above the mouth the creek may be deemed an estuary of Buffalo bay. The vegetable and earthy matter brought down this creek may be considered as kept in motion by the changes produced in the level of the bay; and the creek having remained for many years at about the same average depth, it may be assumed that, in its present form, it will remain clear of obstruction from the same causes. While the earthy and other matter brought down the lake and along the shore, during boisterous weather, towards the mouth of the creek, must be in far greater quantity than that which flows out of the creek, care is needful,

therefore, that at the point about which these floating or moving matters may meet, the constructions of work may not tend to collect and deposit them to impede navigation. When this matter or debris may come into the current off the end of the pier, it is chiefly carried to the river; but it is observed that the current, passing the outer extremity of the pier forms a whirl there, and often throws floating and moving substances out of the current into the action of the waves that reach the beach to the northeast, and then lodge there; or, more gradually, by the travelling of the beach surf, to the northward into Black Rock harbor; which substances, aided by the beach sand, is forming and extending a low sandy shoal from the Buffalo shore, and also lodging a shoal within the harbor, now about six feet below the surface of the water, where formerly flowed the channel between Bird island and the American shore. It has been further observed, that in every fresh breeze, the sea, which impinges against the head of the pier, is aided by the shore or literal current, and becomes a wave setting to the northeast; these waves impede the vessel in luffing to enter the creek; and when the wind is approaching to a gale it increases the difficulty; and, at this point, it becomes imperative to avoid running too far to the northward, which might involve the necessity of anchoring on a rocky bottom. Anchoring, at most places in Buffalo bay, would incur the danger of losing the anchor among the crevices of the rock.

Impediments to the free motion of the water at the outlet of Lake Erie will not, of course, be increased beyond what may be essential to improvement. If it were deemed important to increase the facility of the outlet, such might be obtained by blasting out masses of some of the rocky shoals. But it may be questionable as to the right of increasing or diminishing the level of any part of Lake Erie without the consent of the community affected thereby.

On examining the capacity of the creek, it does not appear to the board that it would afford a ready shelter to the vessels now belonging to the port—that is, such of them as might be driven by stress of weather to seek a harbor; and also, that whatever may be the number of vessels which an energetic and able harbor-master might place in safe and convenient births while the weather was moderate, such births could not be obtained during the prevalence of gales of wind; and however convenient the creek, with adjacent docks and canals would certainly be, such appliances could not subserve the wants of a harbor and shelter for the general navigation of the lake in bad weather; and that, therefore, there should be a harbor not remote from the head of the light-house pier, where vessels may enter with certainty and facility and make fast by anchor or moorings during a gale of wind; and, on the return of moderate weather, either enter the creek or resume the voyage on the lake. Such a harbor, the board believe could be best located adjacent to, and south of the light-house pier, for reasons that will be given in the description thereof. The reasons for which may be considered as among the causes why the board entertain several opinions that differ from those com-

mended to the board by the common council and by others. The board believe that canals and basins adjacent to, and connected with, the creek, would greatly facilitate the commercial business of Buffalo; and, were it permitted to extend the United States work above the mouth of the creek, the board would recommend the execution of so much of Mr. Lovjoy's plan as would open a canal through the elbow. The clearing out Buffalo creek would be useful; but, enlarging and deepening the creek to any great extent, however convenient to navigation, might be followed with consequences not foreseen. The creek, being an estuary of the lake, might be kept clear when enlarged, by the same causes that have kept it so for many years. This subject the board consider to be involved in the contingency alluded to in this report in reference to the "elbow."

*Of a sea wall*, which is by the common council and many citizens deemed to be a necessary safeguard against the eruptions of the lake. It is to be observed that when a flood covers the flat lands, it meets that which flows through the creek, and then the force of the moving water is divided; but if such a wall as is contemplated by the common council be extended four miles to the south, the force of the flood would rush up the creek and speed over the flat lands; and as the creek could not contain a tithe of the volume of the flood, it would probably be destructive to that part of the city situate upon the immediate margin of the creek; and moreover the flood thus forcing itself onward could recede only by the same gorge through which it entered; whereas the low grounds now serve to receive a large part of the flood, and so far it operates beneficially to the city. Moreover, it is doubtful whether a mole on the beach could long stand against the encroachment of the waves in repeated gales of wind, which have of late years, especially, swept off much of the beach in the south bay. The opinion of the board is adverse to the contemplated extension of the wall.

But if it were determined to place a barrier to the encroachment of the lake south of Buffalo, it might be found advisable to raise the present turnpike to form a dyke in addition to its present use; and also to secure the beach by covering it with Fraises (or Groinds), as has been very successfully done upon other beaches; and also to extend the present wall to the dyke, but in such case it would also become necessary to extend the wall across the mouth of the creek and during western gales close the same by means of locks. It will be seen that the proposed plan for a breakwater enters somewhat into the question of protecting the south shore from the violence of the waves.

[NOTE.—Trees were thrown on top of the sea-wall by the flood or combing of the wave in the gale of October, 1844.]

*Of stages of water and abrasion*.—Before the wood was cut from the lake shores at Sandytown bay and south of Buffalo, the encroachments of wind and waves were comparatively small, there



was a small ridge of sand between the shore skirt of the wood and the beach, but since this wood was removed, the winds have blown off the crest of the small ridges and brought them down so low as to come under the action of the surf, and which operation is still going on. Some covering should be placed on the beaches by Fraises or by the cultivation and new growth of willow or other spreading-rooted trees.

From causes not well known the northern lakes have, within late years, had higher water in them than formerly, and the last maximum was in 1838. In Buffalo bay the shores have been much abraded by these waters, and many large trees killed; and at Squaw Island, four miles north of Buffalo, in Niagara river, large trees have been killed by high water. To these high waters a portion of the floods in latter years are justly attributable.

In the year 1809, Lake Erie must have been unusually low. Deacon Callender, in September of that year, drove cattle from Huron, near Sandusky, Ohio, over the lake shore to Buffalo, crossing every stream by wading, save Rock river, the Cuyahoga just reaching the saddle-girth.

The beds of the northern lakes, except Erie, including Seneca Lake, are below the surface of the ocean. In Lake Seneca, it has been observed in swimming that there were various temperatures in contiguous small areas of water, indicative of springs below; other lakes may be similarly influenced. Some light may be given to the subject by measuring the lake outlets and tributary streams, on the question whether more water flows out than is thus measured in the tributaries. In the humid and cold region of the lakes, some variation from ordinary estimates of meteorology may be found of ice. The ice forms in Buffalo bay usually to the thickness of from twelve to fifteen inches. If any large acre of such ice were put in motion by a westerly gale, it would be difficult to place a breakwater in deep water that could resist the pressure and momentum of such a body: for instance, each acre of such ice would be a force of at least thirteen hundred tons, and might impinge against a breakwater with a force of the weight of the body of ice multiplied into the velocity with which the wind and waves might drive it onward. From the inquiries made, it is learned that from the firmness with which the bay and the lake are enclosed by ice, that generally it is not "broken up" in the spring, but soon after northeast winds; and then that the brittleness of the ice has become such that it rapidly breaks into small masses and escapes through the river; but that the ice has occasionally piled on the rocky shoals and in the bay south of Buffalo to many feet in height. Evidently, therefore, avoidable obstructions to the moving ice should not be added to those of the shoals. But in case a "breaking up of winter" should be varied from its ordinary character, and in some future season a westerly gale should come on at the moment of "breaking up," a breakwater should be so placed as to be liable to the least avoidable injury from ice in motion. This subject has been deemed a material element in the calculations for the stability of the breakwater hereafter commended.

In reference to the plan submitted to the board by the bureau, it is supposed that the chief object contemplated by that plan, and also by a revision thereof submitted by its author, was to commend the location of a breakwater in the most eligible position; and upon comparing these views with those taken in reference to the outlet of the lake, the board deem it advisable to place the breakwater somewhat further to the south.

The prominent reasons why the board do not deem it advisable to place a breakwater north of the line marked on the plan in extension of the light-house pier, may be gathered from the foregoing parts of this report and from the description of the location and construction hereafter given to the breakwater.

The board has also considered the advantages that would result from a guarded opening of a channel into the creek from the rear of the contemplated breakwater. It is believed that such an opening might be advantageously made after the construction of the breakwater, somewhat of the form and in the position indicated on the map. The further consideration of this part of the subject, it is respectfully commended to the bureau, that it may be deferred, until more time to mature such a plan can be devoted to it by those officers of the board who have other public duty now pressing upon them.

*Storms, waves and currents.*—The storm of October, 1844, was the severest and raised the water the highest in the memory of the oldest citizens of Buffalo; some persons remember them for more than half a century. Among the phenomena in that gale was the fact that the wind struck the steamboat Chautauque without any premonition. The boat was some ten miles west of Buffalo, and was struck in the stern and broached to in the trough of the sea, at a moment when the water was low in the boiler; in the usual time in supplying water, followed by the act of getting the boat "before the gale," the boat struck the beach at Buffalo. The time employed is conjective and justifies no further opinion than that the distance was passed over in an unusual short period; and this fact, connected with that of the sudden submerging of the lowlands near Buffalo, proved that the wave was of the tidal form or progressive. The prevalent opinion among the lake sailors is that the waves do not exceed ten feet in height, including the highest and lowest surfaces. The waves of so shallow a lake as Erie become waves of translation at long distances from the shore. The depth of Buffalo bay for fifteen miles may not exceed sixty feet, and within one mile of the shore does not exceed thirty feet. The board has assumed ten feet as the height of the wave, and fifteen miles the hour as the maximum of progression, upon which bases the force of waves and ice has been calculated. Of the latter it may be noted that in gales of wind it has been raised on the beach to fifteen feet in height, and sliding over the land some forty feet; and it is also to be noted, that heretofore there have been but small artificial obstacles presented to the motion of ice, which may be a cause of the general impression that ice does but little damage in Buffalo bay.

*Ice Breakers.*—Fields of ice, of at least a mile square, have been seen in motion in Buffalo Bay; thence it may be assumed, as possible, that such a mass of ice may be impelled against a break-water, by the current and wind, and at a rate of at least three feet per second, and, therefore, that it may be questionable whether the structure may maintain its stability without external aid, such as ice-breakers; and it may also be, that one or more of such guards might be ruptured by a float of ice; in such an event, the only remedy would be reparation. The board contemplate either a system of ice-breakers, or to substitute such curve to the face of the wall below its perpendicular as may reflect the motion of the ice. Buffalo Bay may be deemed a triangle of about fifteen miles each side; consequently the area of the bay is about 112 square miles. In the contemplated plan, every foot of break-water would offer a resistance of stability of ninety-three tons. Every one hundred feet front of floating ice, moving at the rate of three feet per second, would be a force of 2711 tons; consequently, every foot front of an acre of ice would be a force of 27 11-100th tons.

The action of the ice, as formerly experienced at the head of the light-house pier, makes it questionable whether, if there were no other reasons, it would be well to extend that pier further into the lake; an extension of many yards would increase the velocity of the current, and thereby increase the danger of forcing vessels towards the Horse Shoe reef, in doubling around the pier-head, a movement that requires caution at the present time, especially at night. The angular small bay now formed by the light-house pier and the South Bay beach, is every winter filled with ice, so sliding upon ice that it becomes a protection to the pier, and in its particular location, the external slope of the pier is the cause of the ice so piling upon ice; which slope it would not be safe to apply to a wall in deep water.

The small bay just mentioned, might be enlarged by extending the pier, and to a depth of twenty feet perhaps, and would insure similar safety to the pier by a sloping wall; but in deeper water, such slope may not be used with safety; and deeper water occurs within fifty yards of the end of the present pier.

*Breakwater.*—Although the board is of opinion that the best position for a breakwater intended to cover an outer harbor for Buffalo, is the position south of the light house pier, and although it intends before this report is closed, to describe the plan which it would recommend for that locality, it thinks, nevertheless, that it is respectfully due to a project which seems to have met with extensive favor, that the department should have before it the plan which on the most careful consideration, the board thinks best adapted to the northern locality.

While the board was occupied in considering the circumstances which ought to determine the details of this work, it had to keep in mind the character of the bottom of the lake, with reference to its ability to serve for a stable foundation. The depth to which it was expedient to carry the structure, namely, with reference to the

economy of construction, to the accommodation of the shipping, and to the energy of the volume of water upon which we have to rely for maintaining the depths already found within the area of the harbor. The area, also, which ought to be given to the anchorage, with reference as well to the sufficiency of the accommodation, as to the protection of the shipping within it, against the force of the winds and sea. While the board desired to give to the harbor all the room that might be requisite to enable vessels to manœuvre without danger to themselves or others, it was limited in this particular by the apprehension of giving so great a breadth of harbor room, that the winds in sweeping over the breakwater, or the waves in setting around its end through the large openings which must be left between them and the shore, should disturb the anchorage by destroying the calm which it is the very object of the work to secure.

With respect to the southern end of the work, it was believed that the wave carried forward by the prevailing winds ought to be allowed to reach the back, or windward side of the light house pier, in order to clear it of the sands which are conveyed to it along the beach, as it is to be apprehended, that if they were not allowed to sweep back these sands into the littoral current, they might find their way along the head of the pier, more effectually than they now do, and that thus they might form a sand spit in prolongation of the pier, and obstruct the passage into the inner harbor, and in this way the board considered that the prolongation of the southern termination of the work should be limited by a line from the head of the light-house pier, or from a point near its head, drawn in the direction of the prevailing storms, namely, in a direction SW. by W.

To the north, the termination of the work is limited to a single point, by reason of the position of the rocky shoal, which, owing to the general character of the bottom, offers the only acceptable position in that vicinity for the northern head of the work.

The two considerations now stated, fixed the length of the breakwater. Its direction was governed by a desire to avoid any unnecessary interruption of the currents, and by the width which (between the southern end of the work and the shoal lying at the head of the light house pier) it will be necessary to leave for vessels entering and departing from the inner and outer harbors in adverse weather. The width which the board has allowed for this purpose is about 560 yards, and it does not suppose that it can be safely reduced, when it considers the room absolutely requisite to enable many of the lake vessels to manœuvre, as well as the possibility of a further extension of the shoal at the light-house pier towards the west.

We thus find the position of the work determined by all the considerations which seem to apply to it. It is traced upon a right line, 5,100 feet long, bearing northeasterly and southwesterly, and making, with the magnetic meridian, an angle of eighteen degrees. It is based, for its whole length, upon the solid rock, and it lies, as nearly as may be, in a direction parallel with the usual currents,



but perpendicular to the line of the prevailing storms, and exposed to the direct shock of the waves. Its northern end is about 900 yards from the shore, and it will enclose an area of some 350 acres, secure from the direct action of the winds coming from the southward and westward; those, namely, which are alone feared by the navigators. The chart and plans will show the lines of direction which have been used for the purpose of fixing the precise position of the southern end of the work; they will also show the horizontal plan of the work itself.

While the board is of opinion that the line selected by it for the position of the work is the best which can be found to the northward of the light house pier, it is quite aware how faulty that position is, especially towards the northern end, where the slope of the rocky shoal may endanger the stability of that part of the work, especially when the ice is breaking up, because, as the department can see on looking at the chart, the western side of the shoal is so formed as to encourage the dangerous accumulation of ice in front and upon the flanks of that part of the structure.

In a previous part of this report, the board has said that it had seen cause for recommending the location of the breakwater to the southward of the light-house pier, rather than to the north of it. Among the reasons which have brought the board to this conclusion are the following: the superior velocity of the currents at the northern locality, whereby the work would be exposed to greater violence as well from floating ice as from the waves—a velocity which must be farther increased by the interruption of the currents by the proposed work; the great extent of rocky and sandy bottom within the area of anchorage, and the consequent insecurity to vessels lying within it during heavy weather; the presence of rocky shoals, which control the position of the work so far as to confine the extent of anchorage within limits which the board consider as being insufficient for the lake trade, viewed with reference to its very rapid increase, and the still further diminution of anchorage room in consequence of the great breadth of the sand shoals along shore. To these may be added the essential objection that for a very great extent (certainly one-third) of the work, the water is so shoal, with rock bottom, that it would not be safe for vessels in harbor to lie along side of this work in very heavy weather; and this objection is the more striking when we recollect how deficient the anchorage is both as to extent and safety.

The board having weighed all these objections, had directed its attention to the question of securing the beach lying south of the light-house pier, and to the project for a southern entrance into the inner harbor or creek, which project had been brought before it by the city council. The creek which constitutes the present harbor of Buffalo, as has already been said, is, for a considerable distance above its mouth, a mere arm of the lake, the waters of which ebb and flow through it with every change of level of the lake, and very frequently with a velocity more than sufficient to convey into the lake the detrital matter brought below the more rapid part of the creek, viz.: to within some three miles of the en-

trance. It seems possible, therefore, that with proper precaution the proposed entrance might be effected without prejudice to the present depth of the creek, and certainly greatly to the convenience of the navigation. The board, while engaged upon these questions, was led to the examination of the part of the bay lying between the proposed entrance and the present light-house pier, and additional surveys were made under its instructions, as had already been done to the northward of the light-house. From even a slight examination of the ground, as developed by these surveys, it became manifest that the southern location was decidedly the superior of the two in all the particulars which have been enumerated while treating of the objections to the more northern position. It was, therefore, resolved to form the plan of a work capable of enclosing a sufficient area in front of the beach between the light-house and the proposed south entrance to the creek, and so to arrange it as not to interfere with the construction of a similar work north of the light-house, nor with the present entrance to the harbor, and to carry it so far to the southward that its southern end should have the same position, relatively to the proposed cut and its dependent pier, that the southern end of the northern breakwater should have with reference to the present light-house pier, namely, that it should unmask the windward side of the southern pier so far as to enable the prevailing waves to sweep back the sands into the littoral currents to windward of that pier, while it covered as great an extent of surface as practicable, under the limitations already named when speaking of the location for the northernmost breakwater.

There should be left an opening of some 480 or 500 yards, between the northern end of this work and the point occupied by the southern end of the other, in a course north  $54^{\circ}$  east, so as to leave sufficient space for vessels to beat out between the works, and at the same time a free space for the wave to reach the back of the light-house pier. This would place the northern end of the work within about 870 yards of the present shore, and 670 yards from the light-house pier shoal. From this point it should extend south  $14^{\circ}$  east, or nearly parallel with the line of direction of the northern work, for a distance of 2,710 feet. It would perhaps, be better to give this line a direction nearer to the south in order that the exterior of the work might present itself to the wave under a more desirable angle, but the board apprehended that as it was quite expedient that the southern portion of the work should be inclined more to the east in order to bring the southern end of it under the protection of land near Four Mile point, that the interior angle would thus become so small as to make still water within that angle, and consequently a shoal alongside of the work. Another objection to the inclination of the first-mentioned part of the work farther west results from the danger that vessels beating out might fall foul of it. Extending this part of the work then in a direction south  $24^{\circ}$  east 3,340 feet, it would be brought to within two miles of Four Mile point, and the southern entrance would be completely under the protection of the land, as would also the northern, and

waves could enter it only by being deflected from their course, and although, undoubtedly they would so enter it, it must be with a diminished velocity.

The arrangements for defending a southern entrance to Buffalo creek would so far resemble those already found to the north of it that the pier would have nearly the same length and direction. There would probably be nearly the same extent of shoal near the pier head, and between it and the southern end of the breakwater the same width of channel to allow vessels to pass in and out against adverse winds.

While the board would hope that in leaving so great an opening as the convenience of navigation seems to call for, they would not be incurring too much the hazard of exposing the anchorage to the injurious action of the waves, it would suggest that if this expectation should prove to be unfounded, the construction of a short dyke oblique to the entrance, as indicated on the chart, at such a distance from the main work as to allow vessels to beat through it, or at much less than 500 yards from the main work, and in such a position as to give abundant room for leeway. Should such a traverse dyke be hereafter found necessary, it would probably be expedient to construct submerged openings in it, sufficient to allow the passage of the current into the harbor so far as to clear it of any sedimentary matter which appeared likely to form shoals within it. The dotted lines near the south entrance shows approximately the position and length of such a work. A cant to the southward might be given to it in order to avoid, as far as practicable, the danger of deflecting the waves into the harbor.

The line traced for the breakwater south of the light-house pier is in 25 to 30 feet water, and generally on a rock bottom, or on clay resting on rock. This flooring is very level for so great a length, and offers great security to the work. The location has, as has already been said, a very decided superiority over that to the north of the light-house, especially as an anchorage, because, over a considerable portion of the bottom there is found by the lead clay and sand. The area covered with water is greater than that occupied by the other projet, as 430 : 330; besides which, owing to its more uniform and greater depth, and to the less breadth of shoal along the beach, the actual area of anchorage, or the berth for shipping, is almost treble; besides which, it is less exposed to the influence of the currents, and in decidedly a less hazardous position with reference to the ice. Like the other work, it will defend from abrasion the beach directly in its rear.

It may be perceived that while arranging the project for a harbor south of the light-house, the board has been careful not to compromise the government with respect to the northern one; so that the construction of the one, if the government so choose, may be received only as a portion of a larger project, which might ultimately include both localities; and should the demands of commerce at some future period require its extension, it might be extended even to Four Mile point; care being had not to interfere

with the freedom and efficiency of the openings between the several divisions of the work, especially in front of the entrances to the inner harbor.

*Cross section.*—The cross section proposed for the work, is 2,237 square feet, and the resistance of the mass  $280\frac{1}{2}$  tons for every linear yard of the breakwater. We will omit the discussion of such facts as we have collected as to the force which the waves of the lake may be expected to exert upon the work, because they are not sufficiently numerous or definite to warrant any very accurate deductions from them. The velocity which has already been described to the great wave of the hurricane of last autumn, although estimated from loose data in our hands, may certainly with great safety be assumed as a maximum, when we compare it with the highest velocities observed by professional men upon the shores of the ocean. If we take the experience upon the southeast coast of England, we find, with but one exception, 26 feet per second as the greatest observed velocity; and at Cherbourg, we are assured that the greatest wave exerts a force of only  $7\frac{1}{4}$  tons upon each square yard, the wave being about 13 feet in height, or  $4\frac{1}{2}$  yards; and this, applied to the proposed breakwater, would be equivalent to less than  $31\frac{1}{2}$  tons upon each running yard. Now, comparing this with the resistance of the section proposed by the board, it will be seen that it so far exceeds the force of any waves that can be generated on Lake Erie, that, with reference to these, the weight of materials in the work, supposing them to be solidly put together, would be greatly in excess. The board, in another part of this report, has spoken of the danger to be apprehended from the ice, and it is with respect to this force that the board thinks itself quite warranted in recommending the adoption not only of this profile, but suggests, as it already has, the possibility that still further precautions may be found necessary for the security of the work.

It will be seen, that for the front of the breakwater, it is proposed, instead of continuing the vertical line down to the foundation, to step it back twice within 16 feet of the bottom, in order to increase the surface of resistance to sliding and also to counteract the effort of the ice or any other force tending to overturn the mass; the breadth of the base is thus increased to 75 feet. The steps are carried to such a depth below the surface of the lake as seemed to the board to be quite below the influence of floating bodies, as well as below any disturbance of the waters of the lake likely to injure that part of the work; the depth of the highest step is 11 feet below extreme low water. On the inner side of the work, also, the vertical line is carried down low enough to permit vessels safely to lie along side. The front, also, is carried to a height of 21 feet above the low water line, and this is presumed to be quite enough to prevent the storm waves from rolling over the parapet, to the prejudice of vessels lying immediately in contact with the inner side of the work. The width of the platform or quay is 20 feet, and its height 9 feet above low water,



and the height of the parapet is 12 feet, and its thickness at top 21 feet and 4 inches, exclusive of the parapet; and the inside has a batten of 2 inches to 1 foot.

Besides snubbing posts 100 feet apart, along the platform of the work, and the requisite arrangement for moving to the inner side of the work, there ought to be a sufficient number of moorings within the harbor, especially wherever there may prove to be a deficiency of holding ground. It would, also, be desirable to place along the inside of the parapet iron ladders, for the purpose of ascending the wall. For further details, the department is referred to the cross section which accompanies this report.

In closing thus much of the subject submitted to the board, it has to subjoin, that from Captain Williams the board has received every facility to aid its examinations, and from Lieutenant Woodruff, the recorder, much professional assistance.

Respectfully submitted,

JAMES KEARNEY,  
*Lieut. Col. T. E.*

WM. TURNBULL, *Major Top. Engs.*  
J. G. SWIFT.

J. C. WOODRUFF,  
*First Lieut. U. S. Top. Engs., and Recorder.*  
To COL. J. J. ABERT,  
*Chief Topographical Engineer.*  
BUFFALO, N. Y., May 21, 1845.

*Estimate for 100 feet in length of breakwater, Buffalo, N. Y.*

#### FIRST TIER OF CRIBS.

For 2,250 cubic feet of timber in each crib, six cents per foot.....	\$135 00
For cost of framing, six cents per foot.....	45 00
For 80 cubic yards of stone in each crib, at 85 cents per yard.....	68 00
	<hr/>
	248 00
Number of cribs in 100 feet in length of breakwater..	12
	<hr/>
	2,976 00
Iron for bolts in 100 feet in length.....	57 60
Beton covering, 139 cubic yards, six inches in thickness, at \$3 per cubic yard.....	417 00
	<hr/>
	3,440 60
	<hr/>

## SECOND TIER OF CRIBS.

For 1,600 cubic feet of timber in each crib, at six cents per cubic foot.....	\$96 00
For framing.....	40 00
For 105 cubic yards of stone, at 85 cents per cubic yard.....	89 25
	<hr/>
	225 25
Number of cribs in 100 feet in length of breakwater..	8
	<hr/>
	1,802 00
Beton filling between cribs, 266 cubic yards, at \$3 per cubic yard.....	798 00
Beton covering, six inches in thickness, 109 cubic yards, at \$3 per yard.....	327 00
Iron for bolts in 100 feet of length.....	57 60
	<hr/>
	2,984 60
	<hr/> <hr/>

## THIRD TIER OF CRIBS.

For 1,288 cubic feet of timber in each crib, at six cents per cubic foot.....	77 28
For cost of framing.....	35 00
For 92 cubic yards of stone, at 85 cents per cubic yard.....	78 20
	<hr/>
	190 48
Number of cribs in 100 feet in length of breakwater..	8
	<hr/>
	1,523 84
Beton covering, two feet in thickness, 3,185 cubic yards, at \$3 per cubic yard.....	955 50
Iron for bolts in 100 feet in length.....	57 60
	<hr/>
	2,536 94
	<hr/> <hr/>

## MASONRY.

For 2,615 cubic yards, (in 100 feet in length,) at \$5 per cubic yard.....	13,075 00
For 3,000 pounds iron, (dowels and clamps,) at 5 cents per pound.....	150 00
For two snubbing posts, at \$20 each.....	40 00
	<hr/>
	13,265 00
	<hr/> <hr/>

## RECAPITULATION.

For first tier of cribs.....	\$3,440 60
For second tier of cribs.....	2,984 60
For third tier of cribs.....	2,536 94
For masonry.....	13,265 00
	<hr/>
	22,227 14
Contingencies, ten per cent.....	2,222 70
	<hr/>
Total cost of 100 feet in length of breakwater.....	24,449 84
	<hr/> <hr/>

## MACHINERY, &amp;c., &amp;c.

For eight scows, at \$350 each.....	2,800 00
For two large crane scows, at \$1,000 each.....	2,000 00
For tools, implements, shantees, &c.....	8,000 00
	<hr/>
	12,800 00
	<hr/> <hr/>

